

Research Report

COMPARISON OF POWER GRIP AND LATERAL PINCH STRENGTHS BETWEEN THE DOMINANT AND NON-DOMINANT HANDS FOR NORMAL CHINESE MALE SUBJECTS OF DIFFERENT OCCUPATIONAL DEMAND

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Abstract: The purpose of this study was to establish handgrip data for right hand dominant normal Chinese subjects. Sixty-four males were studied for their power grip and lateral pinch strengths. They were categorized into non-manual and manual workers. Standardized procedure and instructions were used for handgrip testing. Results showed that both the non-manual and manual workers demonstrated stronger power grip and lateral pinch strengths in their dominant hands. The 10% rule was applicable only for power grip strength of non-manual workers and lateral pinch strength of manual workers. No significant difference was found between the dominant grip strengths in these two groups of subjects. It was recommended that when assessing the progress and outcome of hand rehabilitation, the occupation and demand level of hand use of the patient must be taken into consideration when using the uninjured hand for comparison.

Key words: hand dominance, lateral pinch, occupational demand, power grip

Introduction

Grip strength measurement is one of the standard features of patient examination in a hand clinic [1]. The JamarTM dynamometer and the Preston pinch gauge are the commonest equipment used in the assessment of power grip strength and pinch strength respectively [2–6], and they have been proven to be the most reliable and accurate equipment for measuring power grip and pinch strengths [7]. With a valid and reliable testing procedure, data of grip strength can be generated for clinical usage and research purposes.

It has been suggested that a minimum of 20 pounds of grip strength is the least performance of the hand necessary for most activities of daily living [8]. Handgrip

strength has been suggested as a predictor of postoperative complications [9] because of its high sensitivity and specificity. Reduced handgrip strength has also been suggested as a predictor of disability in older people [10]. In a longitudinal study spanning over 4 years in 620 survivors [11], the significant decline in grip strength was shown to be consistently related to lack of use rather than loss of health. Thus, grip strength data may be used as an indicator of general health status as well as a predictor of major physical disability.

Much research has been carried out to generate normal grip strength values, although published reports are by no means recent articles. Mathiowetz et al [5] established power grip and pinch strength values for normal subjects 6–19 years old, and the results showed

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that increases in power grip and pinch strength coincide with increases in chronological age and that males are stronger than females in all age groups. Petersen et al [6] tested the so-called “10% rule”, which was first described in the 1950s and states that the dominant hand possesses 10% greater grip strength than the non-dominant hand. They concluded that the 10% rule is valid for right-handed persons only and that grip strength should be considered equivalent in both hands for left-handed persons. Crosby et al [12] demonstrated similar findings in hand dominance and substantiated this result in a large-scale study. However, in a study by Armstrong et al [2] comparing the dominant and non-dominant hand strength in both right- and left-handed participants, no significant differences were observed between the dominant and non-dominant sides in left-handed participants, and only small, though significant, differences (0.1–0.3%) were observed between dominant and non-dominant hands in right-handed subjects. A large size study by Hanten et al [3] of normative maximum grip strength in men and women aged 20–64 years showed that significant decreases in grip strength occurred between the age groups of 50–54 and 55–59 years in men, and between the age groups of 50–54 and 60–64 years in women. The study results also indicated that right and left grips were highly correlated with each other, and that gender, height and weight were only moderately correlated with both grips. Possible reasons for the contrary findings from the above studies on the effect of hand dominance on grip strengths may be due to differences in the sampling procedure and that the occupations and hobbies of the subjects were not analysed systematically. A study by Josty et al [13] addressed this issue. They demonstrated that heavy manual workers had the least difference between right and left hands, whereas office workers exhibited the greatest difference between sides. These study results clearly show the implication of the level of demand of hand use when interpreting grip strength performance.

As the demand of hand strength may vary significantly among different types of work, the prediction and evaluation of rehabilitation outcomes may not be generalizable merely by comparing with normative data matching with sex, body weight or body height. The occupation and the demand level of hand use of the patient should also be taken into consideration. Therefore, the objectives of this research study were to: (1) study if there is a significant difference in the power grip and lateral pinch (key pinch) strengths between the dominant and non-dominant hands in normal Chinese right-handed male subjects with different occupational demands; (2) determine if there is significant difference in grip strengths between non-manual and manual workers; and (3) evaluate whether or not the 10% rule in grip strength is applicable for workers with different demand levels of hand use.

Methods

Subjects

Right hand dominant healthy male subjects with no cervical/thoracic/lumbar spine pathologies, brachial plexus injury, upper limb trauma/injury in the past 6 months without full recovery, congenital anomalies, neurological conditions such as cerebral vascular accident, Parkinsonism and any other conditions that may affect handgrip were conveniently sampled and recruited from a local general hospital for this study. They were categorized into two groups, namely non-manual and manual workers, according to their hand use demand levels (light and heavy), and the categorization was based on the classification from the Dictionary of Occupational Titles, US Department of Labor Employment and Training Administration [14].

Equipment

The *Dexter* Hand Evaluation and Therapy System was employed for all the assessments. Such equipment has been shown to provide measurements that are statistically similar to those of their manual counterparts in both normal populations [15] and hand-injured patients [16].

Study design

Power grip and lateral pinch strengths were studied in all subjects. All measurements were made by one observer to minimize interrater variability. For each subject, the power grip strength was measured first using the JamarTM accessory for measuring power grip set at level II to generate maximum grip as recommended by Firrell et al [17]. This was followed by measurement of the lateral pinch using the pinch meter accessory. Hand dominance was determined by asking: “Are you right-handed or left-handed?” If the subject was unsure, the hand used to feed and write decided handedness [10]. Three readings were taken for each test for each hand, and the average was taken for analysis as suggested by Mathiowetz et al [7] for more reliable results. As shown by Young et al [18], power grip and pinch strengths do not vary from morning to afternoon, so data were gathered with no concern for time of day. However, subjects were checked for any exceptionally heavy manual work before the grip tests to avoid possibility of fatigue. Informed consent was obtained from each subject before testing.

All subjects were in clothing that allowed free arm and hand movement and all jewellery was removed from both upper extremities. As long fingernails have been shown to affect grip performance [4], subjects with fingernail length of more than 0.5 cm beyond the tips of the fingers were advised to have them trimmed. Subjects were then seated with their hips and knees flexed at 90° and their feet flat on the floor. As recommended by the American Society of Hand Therapists [19] and other researchers [20–23], all subjects sat with their shoulder

adducted and neutrally rotated, elbow flexed to 90°, forearm in the mid-prone position and wrist in slightly extended position for optimal performance in both power grip and lateral pinch strengths.

The computer monitor was turned to face the observer instead of the subject to avoid possible bias from visual cues. Subjects were allowed to familiarize themselves with each instrument by one submaximal practice trial. Power grip strength was tested first using the Jamar™ beginning with the left hand, which was then followed by the right hand. Subjects were then instructed to squeeze as hard as possible according to the preset sequence of the *Dexter* computer system (3 consecutive squeezes from one hand followed by 3 consecutive squeezes from the other hand). Each subject was instructed to squeeze for 3 seconds and then to break for 3 seconds before the next squeeze. Lateral pinch grip was then followed by using the pinch meter, the test sequence of which was essentially identical to that of the power grip test. Whenever the coefficient of variance (CV) exceeded 10% [24] in a set of data (3 trials) as shown by the computer, the subject was asked to repeat the set of trials once more after a 2-minute break to eliminate fatigue (Trossman et al [9] recommends a rest period of 60 seconds only).

Statistical analysis [25–27] and calculations of the percentage difference

With normality being checked by using the Normal Q-Q plot for each set of data, a 2-sided paired *t* test was used to compare the means within groups, and a 2-sided independent *t* test was used to compare the means of the dominant-hand grip strengths between the non-manual and manual workers. The percentage difference of grip strengths between hands was calculated by dividing the score of the non-dominant hand by the score of the dominant hand, and subtracting this value from 1 [6].

Results

Sixty-four males aged 19–57 years old were recruited for the study. Table 1 shows their demographic data and Table 2 shows their occupations. From the test results,

both the non-manual and manual workers demonstrated statistically significant differences in their power grip strengths between their dominant and non-dominant hands ($p=0.000$ and $p=0.003$, respectively) such that the dominant side was stronger. The non-manual workers demonstrated more than 10% difference between hands, whereas a difference of less than 5% was computed for the manual workers (Table 3). Again, both the non-manual and manual workers demonstrated statistically significant differences in their lateral pinch strengths between their dominant and non-dominant hands ($p=0.004$ and $p=0.000$, respectively), with the dominant side being stronger. However, when looking at the mean percentage difference of lateral pinch strengths between hands, the non-manual workers exhibited only around a 6% difference, whereas up to a 10% difference was demonstrated for the manual worker group (Table 4). Grip strengths of the dominant side (right side) was compared between non-manual and manual workers and no statistically significant difference was demonstrated between these two groups for both power grip ($p=0.149$) (Table 5) and lateral pinch strength ($p=0.170$) (Table 6).

Discussion

From the results of this study, both the mean power grip and lateral pinch strengths are significantly different between hands within each group of subjects. However, the 10% rule is applicable only for the power grip strength of non-manual workers (11.2%) and the lateral pinch strength of manual workers (9.9%). As far as the percentage difference between hands is concerned, the results have exhibited a rather similar pattern to findings from the study carried out by Josty et al [13]. Non-manual workers demonstrated a bigger difference between hands on power grip strength (11.2%) but lesser difference in lateral pinch strength (6.7%), whereas manual workers demonstrated a lesser difference between hands on power grip strength (4.7%) but a bigger difference in lateral pinch strengths (9.9%). Such phenomena may be explained by differences in the nature of work, the working environment, and the objects workers have to handle. Non-manual workers

Table 1. Demographic data of subjects

	Non-manual workers ($n=32$)	Manual workers ($n=32$)
Gender	All male	All male
Hand dominance	All right-handed	All right-handed
Mean age, yr (range)	32.9 (20–53)	38.4 (19–57)
Mean body weight, kg (range)	70.0 (57–78)	70.6 (65–82)
Mean body height, cm (range)	172.2 (164–181)	170.8 (162–182)

seldom encounter heavy objects that demand both hands for lifting, pulling or pushing in their day-to-day work. Thus, unilateral hand activities dominate their work schedule. But then again, for their unilateral hand activities, all they may have to do could well be

writing, type-writing, typing on computer keyboards, filing and so on, which are of low demand level of hand use and the demand for strong lateral pinch is not profound. In contrast, due to the nature of their working environment, manual workers need to handle heavy

Table 2. Variety of occupations of subjects*

Non-manual workers	Manual workers
Hospital ward steward (3)	Construction site worker (20)
Computer operator/I.T. programmer (4)	Car mechanic (2)
Hospital receptionist (4)	Moulding machine operator (1)
Accounting clerk (2)	Goods delivery labourer (4)
Land inspector (1)	Recreational facility assembly and repair worker (1)
Library clerk (1)	Renovation worker/plumber (2)
Security company clerk (1)	Cargo loading labourer (1)
Airline customer service agent (2)	Building repairman (1)
Hotel sales director (1)	
Airport foreman (1)	
Social worker (1)	
Drug dispenser (3)	
Hospital cashier (1)	
Construction site supervisor (1)	
Research assistant (1)	
Property attendant (1)	
Salesman (1)	
Police office clerk (1)	
University clerk (1)	
Primary school clerk (1)	

*Number of subjects shown in parentheses.

Table 3. Power grip strength within groups

	Power grip, kg*		p^{\dagger}	95% CI	Mean difference	Mean percentage difference
	Dominant hand	Non-dominant hand				
Non-manual workers ($n=32$)	39.2 ± 5.9 (24.9–48.3)	34.8 ± 5.3 (22.0–44.9)	0.000	3.2–5.8	4.5	11.2
Manual workers ($n=32$)	41.4 ± 5.9 (28.0–59.7)	39.5 ± 5.2 (27.5–55.8)	0.003	0.7–3.1	1.9	4.7

*Data are presented as mean ± standard deviation (range); † two-tailed. CI = confidence interval.

Table 4. Lateral pinch strength within groups

	Lateral pinch, kg*		p^{\dagger}	95% CI	Mean difference	Mean percentage difference
	Dominant hand	Non-dominant hand				
Non-manual workers ($n=32$)	10.4 ± 1.6 (6.6–14.1)	9.6 ± 1.5 (6.7–15.1)	0.004	0.3–1.3	0.8	6.7
Manual workers ($n=32$)	10.9 ± 1.5 (7.5–13.1)	9.8 ± 1.5 (6.5–13.0)	0.000	0.7–1.6	1.1	9.9

*Data are presented as mean ± standard deviation (range); † two-tailed. CI = confidence interval.

Table 5. Power grip strength between groups

	Non-manual workers (<i>n</i> = 32)	Manual workers (<i>n</i> = 32)	<i>p</i> [†]	95% CI of difference	Mean difference
Dominant hand power grip, kg*	39.2 ± 5.9 (24.9–48.3)	41.4 ± 5.9 (28.0–59.7)	0.149	–5.1–0.8	–2.1

*Data are presented as mean ± standard deviation (range); [†]two-tailed. CI = confidence interval.

Table 6. Lateral pinch strength between groups

	Non-manual workers (<i>n</i> = 32)	Manual workers (<i>n</i> = 32)	<i>p</i> [†]	95% CI of difference	Mean difference
Dominant hand lateral pinch, kg*	10.4 ± 1.6 (6.6–14.1)	10.9 ± 1.5 (7.5–13.1)	0.170	–1.3–0.2	–0.5

*Data are presented as mean ± standard deviation (range); [†]two-tailed. CI = confidence interval.

objects (e.g. pneumatic drilling machines, steel plates, concrete blocks, cement packing, wardrobes, car engines/tires) that demand bilateral hand involvement to accomplish the tasks. Gross power grip difference between hands may well be less. However, whenever unilateral hand activity is mandatory for manual workers (e.g. hammering, screwing), exceptionally strong lateral pinch strength is essential for the action. A resulting bigger difference in lateral pinch strength between hands is therefore explicable.

In the current study, the mean dominant power grip and lateral pinch strengths between non-manual and manual workers showed no significant difference in both grip tests. This is somewhat different from the results observed by Josty et al [13], who found significant differences in both the dominant power grip and lateral pinch strengths between non-manual and manual workers. As seen from the demographic data for the two groups of subjects, they were reasonably matched in terms of their mean age, mean body weight and mean body height. Although Hanten et al [3] stated that height and weight were only moderately correlated with both types of grips, they are significant factors influencing maximum grip strength [12]. Ignoring these data could lead to misinterpretation of the study results, and this is something that apparently occurred in the study by Josty et al [13].

Only male subjects were investigated in this study because it is generally agreed that men have stronger grip strength than women [2,3,5,12] and that they should be investigated separately. Hobby demand has also been suggested to be a significant factor influencing grip strength [12], but was not taken into consideration in this study because of the irregularity with which the subjects engaged in their hobby activities; it was therefore perceived to be a highly subjective measurement in the prediction formula. Whether the hobby habit of this

group of subjects had anything to do with the insignificant difference in power grip between the non-manual and manual workers is therefore not known.

In this study, only right-handed subjects were selected as both Crosby et al [12] and Petersen et al [6] have shown that the 10% rule is applicable in right-handed persons only and that grip strength should be considered equivalent in both hands for left-handed persons. An interesting study performed by Plato et al [28] may be able to explain this phenomenon. They evaluated bilateral hand X-rays of 235 male participants and found that there is an inherent tendency of the right second metacarpal to have more bone than the left regardless of hand dominance. Differential stress due to hand dominance will increase the bilateral difference in the right-handed and reduce it in left-handed persons. Power grip and lateral pinch strengths were investigated in this study simply because these are the commonest postures of the human hand for exertion in daily activities. Whereas the power grip reflects the gross hand power of the human hand, the lateral pinch strength is a useful determinant of thumb function. Any other functional postures of the hand are essentially modifications or adaptations from these two grip postures [29].

Ordinary mechanical JamarTM has been shown to be unable to detect a purposeful and consistently submaximal grip effort [30,31]. The *Dexter* system has therefore incorporated a few more tests aimed at assessing maximum grip strength as well as detecting sincerity of maximum grip effort. They are the *Five Rung Grip Test*, *Sustained Grip Test*, *Rapid Alternating Exchange Grip Test*, and the *Index Grip Test* [24]. Further studies on grip tests in generating normative data may be based on these testing procedures.

The design of the current study certainly has some limitations that may be improved in a number of ways. First of all, the design may be improved by using random

sampling instead of convenient sampling so as to minimize sampling bias. The second point is that although the inclusion and exclusion criteria should have served to facilitate the selection of subjects from the target populations, recruitment of patients who suffered from medical conditions not involving the cervical spine and the upper extremities as grip test subjects could still be arguable. Whether these conditions (e.g. lower back pain, lower extremity injuries) have any correlation with grip strengths is uncertain as no specific study can be retrieved from the available literature; this may be a clinical area that deserves exploring. Thus, using subjects who are free of any medical conditions at the moment of the test may help to eliminate this uncertainty. The third point is that although a standardized procedure was followed during grip strength testing for each subject in this study, implementation of a blinding procedure by not allowing the investigator to know whether the test subject is from the non-manual or manual group may help reduce possible tester bias. This is to eliminate the possible situation of the investigator either intentionally or unintentionally offering more verbal cues during the grip tests to a particular group of subjects, leading to unreliable results. Alternatively, a tape recorder may be chosen to deliver uniform verbal cues to each participant during the tests to eliminate possible bias. The fourth point is that although it was not the objective of this study, two-way ANOVA analysis of the same set of data may be able to better explain whether or not hand dominance and occupation affect power grip and lateral pinch strengths independently or interactively. Finally, and as mentioned previously, lack of computation of the hobby habits of this group of subjects in the data analysis invariably limited the scope of explanation of grip strength performance between non-manual and manual workers.

It must be stressed that grip strength testing is only one of the many domains in the evaluation of the injured or diseased hand. Other modes of assessment should always be considered. Our hand is both a machine and a mechanism. As a machine, it converts muscle action into work, and as a mechanism, it provides precise movements [29]. Evaluation of the human hand must therefore be from a broad spectrum and rehabilitation from a holistic approach.

Conclusion

A standardized procedure together with valid and reliable equipment have been used to generate data on the power grip and lateral pinch strengths of apparently unimpaired Chinese male subjects with different occupational demand levels of hand use. The conclusions of this study are in agreement with a previous overseas study in terms of the percentage difference of grip strengths between the dominant hand and the non-dominant hand. Non-manual

workers demonstrated a bigger difference between hands on power grip strength but lesser difference in lateral pinch strength, whereas manual workers demonstrated a lesser difference between hands on power grip strength but a bigger difference in lateral pinch strengths. However, the results of this study indicated that manual workers are not necessarily stronger in grip strength than non-manual workers when matched for age, sex, body weight and body height despite their higher demand level of hand use. It is recommended that when using power grip and lateral pinch strength measurements to evaluate the progress and outcome of a patient, the occupation of the patient, or at least the physical demand level of hand use of the patient, be taken into consideration when using the uninjured hand for comparison. Further study is recommended to establish grip strength data for normal Chinese female subjects based on similar methodology.

Acknowledgements

The corresponding author would like to thank Dr W.Y. Ip, Associate Professor, Department of Orthopaedic Surgery, Faculty of Medicine, University of Hong Kong, for her valuable advice on this research study. The authors are grateful to the Department of Integrated Rehabilitation Services, Tseung Kwan O Hospital, for permitting the use of the *Dexter* Hand Evaluation and Therapy System and other related facilities for this study.

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